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Research Article

Analyzing the obstacles to the establishment of sustainable supply chain in the textile industry of Bangladesh

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ABSTRACT

Bangladesh's textile sector plays a crucial role in its economy by creating jobs and significantly contributing to export revenue. However, this industry faces challenges, including contaminated water sources and the release of airborne pollutants due to its high-water usage, chemical dyes, and manufacturing processes. Therefore, establishing a sustainable supply chain is essential. This study aims to identify the critical obstacles to establishing a sustainable supply chain. Multi-Criteria Decision Making (MCDM) techniques, such as DEMATEL, help reveal the relationships between different components and determine the relative importance of each in the decision-making model. Meanwhile, Fuzzy TOPSIS proves reliable in situations of uncertainty, allowing for effective ranking of the barriers. The findings indicate that the most pressing barriers include resistance to change and the adoption of innovation, financial constraints or high costs, and a lack of support and commitment from top management. This assessment helps pinpoint crucial obstacles that must be addressed to achieve sustainability in the textile sector. By effectively identifying and eliminating these barriers, this study aims to assist those involved in the industry in their pursuit of a more sustainable future.

1. Introduction

The textile industry significantly boosts the nation's economy by generating export revenue and job opportunities. Known for low labor costs, it produces various textiles like fabrics and clothing, driving global trade and growth [1]. Bangladesh, now the world's twelfth-largest clothing producer, derives approximately 77 % of its foreign exchange and 50 % of its industrial workforce from this sector [2]. The textile industry contributes 81 % to the country's GDP and is its top export earner, with around 5600 factories in operation [3]. The textile sector has a dark side, particularly the release of contaminated water from industrial sources, which poses serious environmental threats and harms living organisms [4]. It ranks just after the oil industry as one of the most polluting industries, negatively impacting all aspects of sustainability: environmental, economic, and social [5]. The industry's supply chain contributes to waste, pollution, and resource depletion, consuming significant amounts of energy, chemicals, and water throughout a product's life cycle. To promote environmental sustainability, clothing designers and supply chains must adopt ecologically and socially responsible design principles [6]. A sustainable supply chain in the textile sector is crucial for minimizing environmental harm, promoting ethical practices, and ensuring long-term profitability. It fosters transparency, reduces waste, and meets consumer demand for eco-friendly products [7]. In today's business climate, prioritizing sustainable supply chain management can provide a competitive edge [8]. While many studies focus on performance and enablers for establishing sustainable supply chains, few address the obstacles to their long-term viability [9–11]. This study aims to identify these critical barriers in Bangladesh's textile sector, which is vital to the country's economy.

The goal of this study is to identify the current issues faced by the textile sector. The barriers identified are sourced from existing literature through an extensive review and are organized in a coherent sequence with the assistance of experts. This organization aims to help researchers gain a better understanding of the field. Various Multi-Criteria Decision Making (MCDM) tools are then employed. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is used to determine how these barriers are interconnected, while the Fuzzy Technique for Order Preference by Similarities to Ideal Solution (TOPSIS) method prioritizes the barriers. The structure of the paper is as follows: The introduction provides a foundation for the research. Section 2 outlines

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Table 1
Selected barriers and their sources.

Sl no.	Denoted by	Barriers	Sources
1	A	Consumer desire for lower prices	[11–13]
2	B	Lack of government support	
3	C	Organizational culture resistance to change	[14–16]
4	D	Lack of green materials, processes and technology	[13,17,18]
5	E	Lack of commitment and support by the top management level	[19–22]
6	F	Lack of training and education about sustainability	[18,23–25]
7	G	Monetary constraints or high costs	[26,27,28,29]
8	H	Resistance to change and adopt innovation	[14,30–32]

the research methodology, which includes the Fuzzy TOPSIS and DEMATEL methodologies. Section 3 presents a discussion that primarily highlights the findings from the applied research methods. Finally, Section 4 includes the conclusions and recommendations derived from the investigation, as well as considerations of constraints and future scope.

This study's originality lies in its data collection from experts in sustainability within Bangladesh's textile industry. It employs two distinct Multi-Criteria Decision-Making (MCDM) tools, each with its own mechanism, addressing different criteria for analysis. As a result, barriers are prioritized in two unique ways. The findings from these methods are compared, with any relevant circumstances discussed in detail. The research follows a two-phase approach: Phase 1 involves a preliminary assessment to identify the barriers hindering Sustainable Supply Chain Management, while Phase 2 focuses on determining the primary barriers.

2. Methodology

2.1. Identification of barriers

There are two categories of barriers to implementing sustainable supply chain management (SSCM): internal and external [12]. Through literature review and expert opinions, eight key barriers were identified (Table 1). External barriers include insufficient regulations, unreliable metrics for performance evaluation, and low market demand for sustainable products [13]. Internal barriers involve organizational challenges such as financial constraints, lack of knowledge and awareness, and insufficient support from senior management [14].

2.2. Dimensions of a sustainable supply chain

Sustainability in engineering encompasses social, environmental, and economic issues. It involves balancing economic development, environmental stewardship, and social equity [33]. The triple bottom line theory advocates for businesses to enhance the economy, society, and environment for long-term benefits [34]. In Bangladesh's textile sector, addressing challenges like fair labor standards and worker empowerment is essential for social sustainability [35]. Economic sustainability in this sector requires balancing expansion, resource efficiency, and financial stability, focusing on productivity, innovation, and market growth while managing debts and production stability [36–38].

Ensuring environmental sustainability in Bangladesh's textile industry is essential for reducing ecological impact. Key strategies include adopting eco-friendly production processes, decreasing water and energy consumption, and implementing waste management policies. As global consumers increasingly favor eco-friendly products, these environmental concerns are increasingly linked to trade [39–40]. Barriers to sustainability are analyzed using DEMATEL and Fuzzy TOPSIS, clarifying relationships and ranking elements [41–43]. Both methods will serve as benchmarks for future studies [44]. This approach aligns with Ronald Fisher's Design of Experiments (DOE), allowing for thorough analysis and minimizing confounding variables [45].

Table 2
Pairwise comparison matrix of an expert's opinion.

	A	B	C	D	E	F	G	H
A	0	1	2	2	2	3	2	2
B	2	0	2	1	2	2	3	2
C	2	2	0	1	2	3	2	2
D	1	2	2	0	3	2	2	2
E	1	1	3	2	0	2	1	2
F	2	2	2	3	2	0	1	2
G	2	3	3	2	1	1	0	2
H	2	2	2	3	3	2	3	0

Table 3
Normalized direct-relation matrix.

	A	B	C	D	E	F	G	H
A	0.000	0.072	0.140	0.092	0.160	0.116	0.164	0.124
B	0.092	0.000	0.136	0.132	0.108	0.124	0.148	0.124
C	0.120	0.112	0.000	0.096	0.148	0.160	0.136	0.156
D	0.128	0.120	0.120	0.000	0.128	0.124	0.164	0.148
E	0.096	0.120	0.136	0.124	0.000	0.136	0.108	0.140
F	0.108	0.092	0.128	0.108	0.120	0.000	0.112	0.156
G	0.124	0.104	0.132	0.148	0.144	0.112	0.000	0.152
H	0.120	0.124	0.144	0.116	0.136	0.132	0.128	0.000

2.3. DEMATEL

The DEMATEL method determines causal dependencies among predefined factors, helping to identify critical barriers that need immediate attention [46–49]. It relies on expert judgment rather than sample size and effectively analyzes relationships in complex systems [50]. By creating a visual representation of interrelated elements, DEMATEL clarifies interconnectedness and aids in complex decision-making [51]. The approach follows criteria from Zhan et al. in Evaluatology, changing one factor at a time to ensure accurate results. This method ultimately establishes cause-effect relationships among controlled factors [44].

The following steps are to be followed to carry out a full-fledged DEMATEL analysis:

- ***Step 1: Expert opinions are gathered:*** A questionnaire is developed based on selected barriers and distributed to experts for their input, which is then documented. Responses are assigned numerical values on a scale from 0 (No influence) to 4 (Very high impact). Pairwise matrices (Table 2) are created from expert feedback, leading to a combined matrix using a specific formula:

$$A = \left[A_{ij}\right]_{n\times n} = \frac{1}{H}\sum_{k=1}^{H}\left[X_{ij}^{k}\right]_{n\times n} \tag{1}$$

In the above formula, H is the number of experts, and n is the number of barriers. Each expert provides the impact of barrier i on barrier j. The impacts are presented in the matrix $X^k = \left[X_{ij}^{k}\right]_{n\times n}$.

- ***Step 2: Normalized primary direct matrix is computed:*** This normalized primary direct matrix (Table 3) is also known as initial influence matrix, D. The following formula is used for this step:

$$D = \frac{A}{S} \tag{2}$$

Table 4
Total relationship matrix.

	A	B	C	D	E	F	G	H
A	0.782	0.813	1.032	0.890	1.058	0.988	1.062	1.078
B	0.865	0.743	1.026	0.921	1.013	0.992	1.048	1.076
C	0.933	0.888	0.962	0.940	1.099	1.074	1.092	1.158
D	0.947	0.900	1.076	0.859	1.092	1.051	1.124	1.160
E	0.862	0.845	1.021	0.908	0.909	0.996	1.010	1.082
F	0.844	0.795	0.982	0.866	0.983	0.844	0.980	1.059
G	0.932	0.877	1.072	0.975	1.090	1.029	0.968	1.148
H	0.913	0.878	1.064	0.935	1.066	1.029	1.064	0.998

Table 5
Cause and effect determination.

Indicated as	Barriers	R_i	C_i	R_i-C_i	Identity
A	Consumer desire for lower prices	7.703	7.077	0.626	Cause
B	Lack of government support	7.683	6.738	0.945	Cause
C	Organizational culture resistance to change	8.146	8.235	−0.089	Effect
D	Lack of green materials, processes and technology	8.208	7.293	0.915	Cause
E	Lack of commitment and support by the top management	7.633	8.310	−0.677	Effect
F	Lack of training and education about sustainability	7.353	8.004	−0.651	Effect
G	Monetary constraints or high costs	8.091	8.348	−0.257	Effect
H	Resistance to change and adopt innovation	7.946	8.758	−0.812	Effect

Table 6
Rank of the barriers by DEMATEL method.

Indicated as	Barriers	R_i	C_i	R_i+C_i	Rank
A	Consumer desire for lower prices	7.703	7.077	14.780	7
B	Lack of government support	7.683	6.738	14.421	8
C	Organizational culture resistance to change	8.146	8.235	16.381	3
D	Lack of green materials, processes and technology	8.208	7.293	15.501	5
E	Lack of commitment and support by the top management level	7.633	8.310	15.943	4
F	Lack of training and education about sustainability	7.353	8.004	15.357	6
G	Monetary constraints or high costs	8.091	8.348	16.439	2
H	Resistance to change and adopt innovation	7.946	8.758	16.704	1

Where,

$$S = \max\left(max\sum_{j=1}^{n} a_{ij},\ max\sum_{i=1}^{n} a_{ij} \right) \tag{3}$$

- ***Step 3: Direct/Indirect influence matrix is calculated:*** The interrelationships between the matrix elements are demonstrated in this matrix through both direct and indirect effects. I denoted identity matrix. T, the total relation matrix (Table 4), which is computed using:

Table 7
Cause and effects by threshold value.

	A	B	C	D	E	F	G	H
A	0.782	0.813	1.032	0.890	1.058	0.988	1.062	1.078
B	0.865	0.743	1.026	0.921	1.013	0.992	1.048	1.076
C	0.933	0.888	0.962	0.940	1.099	1.074	1.092	1.158
D	0.947	0.900	1.076	0.859	1.092	1.051	1.124	1.160
E	0.862	0.845	1.021	0.908	0.909	0.996	1.010	1.082
F	0.844	0.795	0.982	0.866	0.983	0.844	0.980	1.059
G	0.932	0.877	1.072	0.975	1.090	1.029	0.968	1.148
H	0.913	0.878	1.064	0.935	1.066	1.029	1.064	0.998

$$T = D(I - D)^{-1} \tag{4}$$

- ***Step 4: Ri and Ci matrices are calculated.*** Using the following formulas, the Ri and Ci values are determined:

$$Ri = \left(\sum_{i=1}^{n} t_{ij} \right)_{1\times n} \tag{5}$$

$$Ci = \left(\sum_{j=1}^{n} t_{ij} \right)_{n\times 1} \tag{6}$$

$$T = \left[t_{ij}\right]_{n\times n} i \tag{7}$$

Using the achieved values, we can determine Ri+Ci (the Total impacts provided and accepted by a barrier) and Ri-Ci (the overall effect contributed to the system by a barrier). If Ri-Ci is positive, it is a cause; otherwise, it is an effect.

- ***Step 5: Assessing based on threshold (Alpha) value:*** Determining the threshold value aids cause-and-effect identification and is optional. It is calculated by finding the mean of all values in the overall influence matrix, which is 0.981 in this case. Barriers C (1.032), E (1.058), F (0.988), G (1.062), and H (1.078) exceed this threshold, indicating that barrier A impacts them. Table 7 shows the cause and effects on the basis of the threshold value.

2.4. *Fuzzy TOPSIS*

Many real-life decisions depend on ambiguous evaluation data [52]. TOPSIS is a decision-making technique that aids in selecting the best option among various choices [53]. Fuzzy set theory addresses uncertainties from imprecision, enhancing decision quality [54–55]. Decision makers often use vague terms like "good" or "poor," leading to fuzziness in attribute weighting [56]. Triangular fuzzy numbers represent these linguistic expressions. The TOPSIS approach, introduced by Hwang and Yoon in 1981, selects options that are far from the negative-ideal solution and close to the positive-ideal one, based on precise attribute values and weights [57].

Table 8
Linguistic variables representing the significance weight of each criterion.

Linguistic Variable	Fuzzy Number
Extremely Low	(0,0,1)
Very Low	(0,1,3)
Low	(1,3,5)
Medium	(3,5,7)
High	(5,7,9)
Very High	(7,9,10)
Extremely High	(9,10,10)

Table 9
Integrated matrix.

Barriers	Social			Economic			Environmental		
A	3.7778	5.2778	6.6667	3.8889	5.5000	7.1667	2.8889	4.2222	5.8333
B	4.5556	5.8889	7.2222	2.0000	3.5000	5.3333	3.8333	5.2222	6.5556
C	5.6667	7.1111	8.2222	3.5000	5.0000	6.6667	2.0556	3.3889	5.2222
D	2.4444	3.7778	5.3333	3.3333	4.7222	6.2222	4.1667	5.8889	7.4444
E	3.1111	4.2778	5.6111	3.5556	5.1667	6.8333	2.2222	3.7778	5.5556
F	3.1111	4.2778	5.6111	4.8889	6.3333	7.5000	4.3889	5.9444	7.2778
G	3.1111	4.4444	5.9444	2.1667	3.3889	4.8889	3.1111	4.4444	5.9444
H	3.8333	5.4444	6.7778	4.5556	6.0556	7.3333	2.1111	3.3889	5.0556

Table 10
Normalized matrix.

Barriers	Social			Economic			Environmental		
A	0.6471	0.4632	0.3667	0.6286	0.4444	0.3411	0.8462	0.5789	0.4190
B	0.5366	0.4151	0.3385	1.2222	0.6984	0.4583	0.6377	0.4681	0.3729
C	0.4314	0.3438	0.2973	0.6984	0.4889	0.3667	1.1892	0.7213	0.4681
D	1.0000	0.6471	0.4583	0.7333	0.5176	0.3929	0.5867	0.4151	0.3284
E	0.7857	0.5714	0.4356	0.6875	0.4731	0.3577	1.1000	0.6471	0.4400
F	0.7857	0.5714	0.4356	0.5000	0.3860	0.3259	0.5570	0.4112	0.3359
G	0.7857	0.5500	0.4112	1.1282	0.7213	0.5000	0.7857	0.5500	0.4112
H	0.6377	0.4490	0.3607	0.5366	0.4037	0.3333	1.1579	0.7213	0.4835

The steps to be followed in order to completion of the Fuzzy TOPSIS method:

- ***Step 1: Utilize the opinions of experts and use linguistic factors to assess the importance of attribute weights and ratings for various possibilities***: A questionnaire with 24 questions focused on social, economic, and environmental criteria, along with eight barriers, was distributed to textile industry experts. Their responses were recorded, and triangular fuzzy numbers (Table 8) were used to assign weightage based on their ratings.
- ***Step 2: The ratings of barriers and weights of criteria are combined:*** The criteria weights and barrier ratings are combined (Table 9) using the following calculation:

$$\widetilde{w}_j = \frac{1}{t}[\ \widetilde{w}_j^1 + \widetilde{w}_j^2 + \ldots + \widetilde{w}_j^t \tag{8}$$

$$\widetilde{a}_{ij} = \frac{1}{t}[\ \widetilde{a}_{ij}^1 + \widetilde{a}_{ij}^2 + \ldots + \widetilde{a}_{ij}^t \tag{9}$$

In the abovementioned equations, 't' is the number of decision-makers. The aggregated ratings a_{ij} of barriers x_j for attribute G_i and the average weight $\widetilde{w}_i$ of attribute G_i can be determined. It is generally assumed that each expert has the same knowledge base. However, that is inaccurate, as we know that not everyone has the same expertise in a specific domain.

- ***Step 3: Normalize the complex fuzzy decision matrix:*** Here, the complex fuzzy decision matrix $\widetilde{A} = (\widetilde{a}_{ij})_{s\times n} = [a_{lij},\ a_{mij},\ a_{uij}]_{s\times n}$ is normalized (Table 10) into a corresponding matrix in the form of $\widetilde{R}^{(\mathscr{k})} = \left(\widetilde{r}_{ij}^{(\mathscr{k})}\right)_{s\times n}$, Where:

$$\widetilde{r}_{ij} = \left(\frac{a_{lij}}{a_{ui}^*}, \frac{a_{mij}}{a_{ui}^*}, \frac{a_{uij}}{a_{ui}^*}\right),\ i\ \epsilon\ B \tag{10}$$

$$\widetilde{r}_{ij} = \left(\frac{a_{\bar{li}}}{a_{uij}}, \frac{a_{\bar{li}}}{a_{mij}}, \frac{a_{\bar{li}}}{a_{lij}}\right), i\ \epsilon\ C \tag{11}$$

And,

$$a_{ui}^* = \max a_{uij,} \qquad i\ \epsilon\ B \tag{12}$$

$$a_{li}^- = \max a_{lij,} \qquad i\ \epsilon\ C \tag{13}$$

In the formulas, B represents benefit criteria and C represents cost criteria. Benefit criteria are desirable characteristics to optimize, with higher values being more advantageous. The goal is to maximize these advantages. In contrast, cost criteria indicate elements to minimize, with lower values being preferable. The objective here is to reduce expenses associated with each criterion.

- ***Step 4: Develop the weighted normalized fuzzy decision matrix:*** Utilizing the formula, the weighted normalized fuzzy decision matrix $\widetilde{V}$ (Table 11) is calculated:

$$\widetilde{V} = [\widetilde{v}_{ij}]_{m\times n} \tag{14}$$

Table 11
Weighted normalized matrix.

Barriers	Social			Economic			Environmental		
A	0.4982	0.4307	0.3667	0.4840	0.4133	0.3411	0.6515	0.5384	0.4190
B	0.4132	0.3860	0.3385	0.9411	0.6495	0.4583	0.4910	0.4353	0.3729
C	0.3322	0.3197	0.2973	0.5378	0.4547	0.3667	0.9157	0.6708	0.4681
D	0.7700	0.6018	0.4583	0.5647	0.4814	0.3929	0.4517	0.3860	0.3284
E	0.6050	0.5314	0.4356	0.5294	0.4400	0.3577	0.8470	0.6018	0.4400
F	0.6050	0.5314	0.4356	0.3850	0.3589	0.3259	0.4289	0.3824	0.3359
G	0.6050	0.5115	0.4112	0.8687	0.6708	0.5000	0.6050	0.5115	0.4112
H	0.4910	0.4176	0.3607	0.4132	0.3754	0.3333	0.8916	0.6708	0.4835

Table 12
FPIS (A*) & FNIS(A-).

	Social			Economic			Environmental		
A*	0.7700	0.6018	0.4583	0.8687	0.6708	0.5000	0.8916	0.6708	0.4835
A-	0.3322	0.3197	0.2973	0.3850	0.3589	0.3259	0.4289	0.3824	0.3359

Where,

$$\tilde{v}_{ij} = \tilde{w}_i \times \tilde{r}_{ij} \tag{15}$$

- ***Step 5: Calculate the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS):*** The FPIS (A^*) and the FNIS (A^-) are computed using the following sets of formulas in Table 12:

$$A^* = \{\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_s^*\} \tag{16}$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_s^-\} \tag{17}$$

To simplify the calculation, FPIS and FNIS can be written as $\tilde{v}_i^* = [1,1,1]$ and $\tilde{v}_i^- = [0,0,0]$

- ***Step 6: Calculate the distance of each barrier from A^* and A^-:*** From the following equations, the distance of each barrier from FPIS and FNIS is calculated:

$$d_j^* = \sum_{i=1}^{s} d(\tilde{v}_{ij}, \tilde{v}_i^*), \tag{18}$$

$$d_j^- = \sum_{i=1}^{s} d(\tilde{v}_{ij}, \tilde{v}_i^-), \tag{19}$$

- ***Step 7: Calculate the closeness coefficient of each barrier.*** The closeness coefficient of each barrier is determined using the following formula:

$$CC_i = \frac{d_j^-}{d_j^* + d_j^-} \tag{20}$$

- ***Step 8: Rank the barriers:*** The barriers are then ranked using the closeness coefficient. According to this method, the barrier with the highest closeness coefficient will be ranked as the number one barrier. [55].

3. Discussion

This study identified and prioritized barriers within the textile sector of Bangladesh. Firstly, a DEMATEL analysis was conducted using a questionnaire distributed to experts. The objective of this study was to examine the interconnections among the barriers and evaluate their relative significance in influencing workers' decision-making processes. The primary goal was to determine the causes and effects of the identified barriers. In this analysis, if the value of Ri-Ci was negative, the barrier was classified as an effect; if it was positive, it was categorized as a cause. Among the eight identified barriers, three were classified as causes, while the remaining five were deemed effects, as shown in Table 5. Cause-based barriers are considered more critical than those based solely on their impact. Conversely, effect-based barriers are generally seen as dependable. According to the analysis, the barriers identified as causes were: consumer demand for low prices (A), lack of government support (B), and lack of green materials, processes, and technology (D). These three barriers were found to be the underlying reasons for the other five barriers all are evident in Fig. 1.

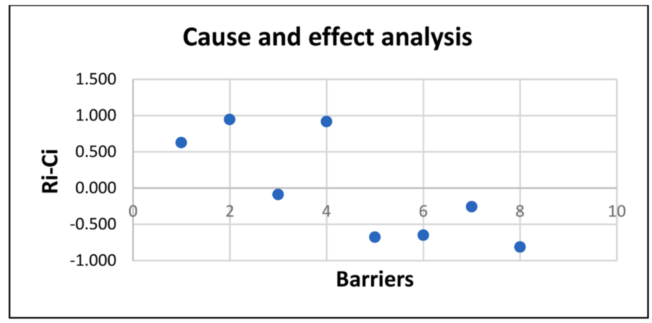

Fig. 1. Cause-effect digraph.

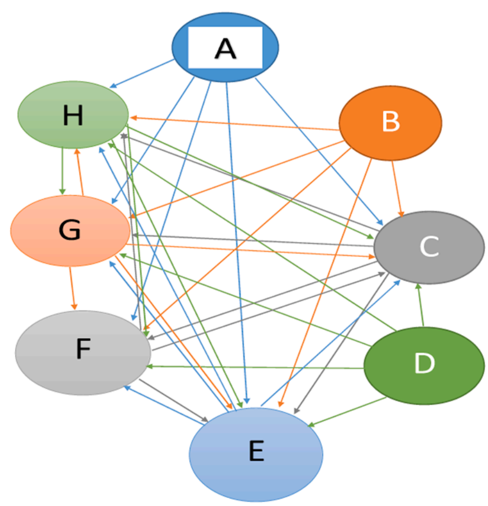

Fig. 2. Impact diagram.

Table 13
Barriers ranked by Fuzzy TOPSIS.

Barriers	Name of barriers	CCi	Rank
A	Consumer desire for lower prices	0.6865	7
B	Lack of government support	0.7262	5
C	Organizational culture resistance to change	0.7218	6
D	Lack of green materials, processes and technology	0.7384	4
E	Lack of commitment and support by the top management level	0.7993	2
F	Lack of training and education about sustainability	0.6203	8
G	Monetary constraints or high costs	0.8496	1
H	Resistance to change and adopt innovation	0.7398	3

After identifying the causes and effects, we ranked the barriers based on their significance using the Ri + Ci method (as shown in Table 6). It was determined that resistance to change and adoption of innovation (H) ranked first, while monetary constraints or high costs (G) and resistance to change within organizational culture (C) ranked second and third, respectively. Subsequently, by utilizing the threshold value, we assessed the impact of each barrier on the others which is shown in Fig. 2.

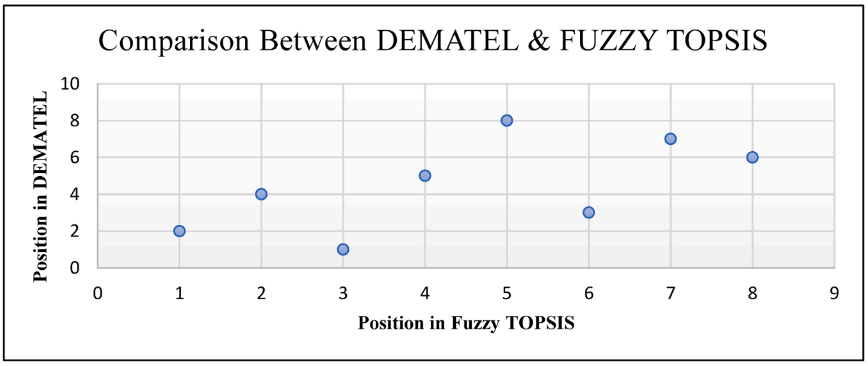

Fig. 3. Rank of barriers through DEMATEL and Fuzzy TOPSIS.

Table 14
Most Critical Barriers as recognized by previous papers.

References	Country	Name of the barrier
[4]	India	Communication gap among stakeholders
[58]	India	lack of effective governmental policies
[59]	Bangladesh	Insufficient financial incentives
[60]	Pakistan	Lack of ability to design a green product

After the DEMATEL analysis, the Fuzzy TOPSIS method was applied, leading to a ranking of barriers based on the closeness coefficient (Table 13). The analysis identified the most critical barrier as Monetary constraints (G), followed by Lack of support from top management (E), and Resistance to change (H). The results from DEMATEL and Fuzzy TOPSIS showed slight differences, as depicted in Fig. 3.

Although the results are similar, they differ because DEMATEL focuses on identifying key elements through cause-and-effect relationships, while Fuzzy TOPSIS uses fuzzy logic to address ambiguities in decision criteria. DEMATEL emphasizes interrelationships, whereas Fuzzy TOPSIS manages uncertainty.

Table 14 shows that different studies have identified various critical barriers. This variation is due to factors like differing production scales, labor costs, environmental practices, and technological advancements in the countries involved. If these factors are similar, the methodologies used may differ. For example, Rashid et al.'s study on Bangladesh presents different findings due to its distinct approach compared to this study.

4. Conclusion

This paper examines the barriers to sustainable supply chains in Bangladesh's textile industry, identifying eight key hurdles based on recent studies. Utilizing the MCDM technique, expert opinions were gathered to assess the criticality and influence of these barriers. Two methods, DEMATEL and Fuzzy TOPSIS, were employed. DEMATEL analyzed the interrelations between barriers and classified them into cause-and-effect groups, considering the insights of 18 industry experts. Although companies may face varied issues, common barriers emerged due to the industry's nature. Three barriers were identified as primary causes, illustrating how a small factor can have complex effects. The barriers were ranked, with resistance to change and innovation (H) in the top spot, followed by monetary constraints (G) and organizational culture resistance (C). Fuzzy TOPSIS further highlighted that monetary constraints (G), lack of top management support (E), and resistance to change (H) are the main obstacles.

4.1. Limitations and future scope of the work

This research has several theoretical and methodological constraints. Firstly, only eight barriers are selected for analysis, limiting accuracy and length. A broader questionnaire may lead to reduced engagement from experts, resulting in random responses. Additionally, treating all expert opinions equally overlooks varying levels of knowledge, and biases may affect their scaling of barriers. The study is focused solely on SSCM procedures within the textile industry, making conclusions inapplicable to other sectors. Future research could validate these findings and explore other MCDM tools like AHP, grey theory, or ANP for comparative analysis.

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CRediT authorship contribution statement

Md. Hasibul Hasan Hemal: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Farjana Parvin:** Writing – review & editing, Validation, Supervision, Methodology. **Alberuni Aziz:** Writing – review & editing, Validation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare no competing financial interests or personal relationships influencing this work.

Data availability

Data will be made available on request.

References

[1] S. Imran, M.A. Mujtaba, M.M. Zafar, A. Hussain, A. Mehmood, U.E. Farwa, T. Korakianitis, M.A. Kalam, H. Fayaz, C.A. Saleel, Assessing the potential of GHG emissions for the textile sector: a baseline study, Heliyon. 9 (2023) e22404, https://doi.org/10.1016/j.heliyon.2023.e22404.

[2] M.M. Islam, K. Mahmud, O. Faruk, M.S. Billah, Textile dyeing industries in Bangladesh for sustainable development, Int. J. Environ. Sci. Dev. (2011) 428–436, https://doi.org/10.7763/ijesd.2011.v2.164.

[3] S. Afrin, H.R. Shuvo, B. Sultana, F. Islam, A.A. Rus'd, S. Begum, M.N. Hossain, The degradation of textile industry dyes using the effective bacterial consortium, Heliyon. 7 (2021) e08102, https://doi.org/10.1016/j.heliyon.2021.e08102.

[4] A.S.M.M. Hasan, M. Rokonuzzaman, R.A. Tuhin, S.Md. Salimullah, M. Ullah, T. H. Sakib, P. Thollander, Drivers and Barriers to industrial energy efficiency in textile Industries of Bangladesh, Energies 12 (2019) 1775, https://doi.org/10.3390/en12091775.

[5] A. Vishwakarma, G.S. Dangayach, M.L. Meena, S. Gupta, Analysing barriers of sustainable supply chain in apparel & textile sector: a hybrid ISM-MICMAC and DEMATEL approach, Cleaner Logist. Supply Chain 5 (2022) 100073, https://doi.org/10.1016/j.clscn.2022.100073.

[6] A. Becker, T. Gries, 26 Sustainability in the textile industry. De Gruyter eBooks, 2023, pp. 473–480, https://doi.org/10.1515/9783110670776-026.

[7] L. Shen, L. Olfat, K. Govindan, R. Khodaverdi, A. Diabat, A fuzzy multi-criteria approach for evaluating green supplier's performance in the green supply chain

with linguistic preferences, Resour., Conserv. Recycl. 74 (2013) 170–179, https://doi.org/10.1016/j.resconrec.2012.09.006.
[8] S. Seuring, M. Müller, From a literature review to a conceptual framework for sustainable supply chain management, J. Clean. Prod. 16 (2008) 1699–1710, https://doi.org/10.1016/j.jclepro.2008.04.020.
[9] A.A. Hervani, M.M. Helms, J. Sarkis, Performance measurement for green supply chain management, Benchmarking 12 (2005) 330–353, https://doi.org/10.1108/14635770510609015.
[10] Mohd.N. Faisal, Analysing the barriers to corporate social responsibility in supply chains: an interpretive structural modelling approach, Int. J. Logist. 13 (2010) 179–195, https://doi.org/10.1080/13675560903264968.
[11] M.Y. Tay, A.A. Rahman, Y.A. Aziz, S. Sidek, A Review on Drivers and Barriers towards Sustainable Supply Chain Practices, Int. J. Soc. Sci. Humanity 5 (2015) 892–897, https://doi.org/10.7763/ijssh.2015.v5.575.
[12] R.J. Orsato, Competitive Environmental Strategies: when Does it Pay to Be Green? Calif. Manage. Rev. 48 (2006) 127–143, https://doi.org/10.2307/41166341.
[13] A. Sajjad, G. Eweje, D. Tappin, Managerial perspectives on drivers for and barriers to sustainable supply chain management implementation: evidence from New Zealand, Bus. Strategy. Environ. 29 (2019) 592–604, https://doi.org/10.1002/bse.2389.
[14] V. Midha and A. Mukhopadhyay, Recent trends in traditional and technical textiles, 2021. https://doi.org/10.1007/978-981-15-9995-8.
[15] A.M. Kitsis, I.J. Chen, Do stakeholder pressures influence green supply chain Practices? Exploring the mediating role of top management commitment, J. Clean. Prod. 316 (2021) 128258, https://doi.org/10.1016/j.jclepro.2021.128258.
[16] A. Lisa Allison, E. Ambrose-Dempster, T. Domenech Aparsi, M. Bawn, M. Casas, The environmental dangers of employing single-use face masks as part of a COVID-19 exit strategy, UCL Press J. (2020), https://doi.org/10.14324/111.444/000031.v1.
[17] A. Paulraj, I.J. Chen, C. Blome, Motives and performance Outcomes of Sustainable Supply chain Management Practices: a Multi-theoretical perspective, J. Bus. Ethics 145 (2015) 239–258, https://doi.org/10.1007/s10551-015-2857-0.
[18] D. Delmonico, C.J.C. Jabbour, S.C.F. Pereira, A.B.L. De Sousa Jabbour, D.W. S. Renwick, A.M.T. Thomé, Unveiling barriers to sustainable public procurement in emerging economies: evidence from a leading sustainable supply chain initiative in Latin America, Resour., Conserv. Recycl. 134 (2018) 70–79, https://doi.org/10.1016/j.resconrec.2018.02.033.
[19] M. Movahedipour, J. Zeng, M. Yang, X. Wu, An ISM approach for the barrier analysis in sustainable supply chain management, Manage. Decis. 55 (2017) 1824–1850, https://doi.org/10.1108/md-12-2016-0898.
[20] A. Majumdar, S. Sinha, Modeling the barriers of green supply chain management in small and medium enterprises, Manage. Environ. Qual. 29 (2018) 1110–1122, https://doi.org/10.1108/meq-12-2017-0176.
[21] K. Govindan, M. Kaliyan, D. Kannan, A.N. Haq, Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process, Int. J. Prod. Econ. 147 (2014) 555–568, https://doi.org/10.1016/j.ijpe.2013.08.018.
[22] G. Soni, S. Prakash, H. Kumar, S.P. Singh, V. Jain, S.S. Dhami, An interpretive structural modeling of drivers and barriers of sustainable supply chain management, Manage. Environ. Qual. 31 (2020) 1071–1090, https://doi.org/10.1108/meq-09-2019-0202.
[23] R.-J. Lin, R.-H. Chen, T.-H. Nguyen, Green supply chain management performance in automobile manufacturing industry under uncertainty, Procedia: Soc. Behav. Sci. 25 (2011) 233–245, https://doi.org/10.1016/j.sbspro.2011.10.544.
[24] H.T.S. Caldera, C. Desha, L. Dawes, Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean' SMEs, J. Clean. Prod. 218 (2019) 575–590, https://doi.org/10.1016/j.jclepro.2019.01.239.
[25] A. Sajjad, G. Eweje, D. Tappin, Sustainable supply chain management: motivators and barriers, Bus. Strategy. Environ. 24 (2015) 643–655, https://doi.org/10.1002/bse.1898.
[26] A.A. Teixeira, C.J.C. Jabbour, A.B.L. De Sousa Jabbour, H. Latan, J.H.C. De Oliveira, Green training and green supply chain management: evidence from Brazilian firms, J. Clean. Prod. 116 (2016) 170–176, https://doi.org/10.1016/j.jclepro.2015.12.061.
[27] A.K.M.A.H. Asif, An overview of sustainability on apparel manufacturing industry in Bangladesh, Sci. J. Energy Eng. 5 (1) (2017), https://doi.org/10.11648/j.sjee.20170501.11.
[28] S.A. Zaabi, N.A. Dhaheri, A. Diabat, Analysis of interaction between the barriers for the implementation of sustainable supply chain management, Int. J., Adv. Manuf. Technol. 68 (2013) 895–905, https://doi.org/10.1007/s00170-013-4951-8.
[29] N. Bhanot, P.V. Rao, S.G. Deshmukh, Enablers and barriers of sustainable manufacturing: results from a survey of researchers and industry professionals, Procedia CIRP. 29 (2015) 562–567, https://doi.org/10.1016/j.procir.2015.01.036.
[30] A. Esfahbodi, Y. Zhang, G. Watson, Sustainable supply chain management in emerging economies: trade-offs between environmental and cost performance, Int. J. Prod. Econ. 181 (2016) 350–366, https://doi.org/10.1016/j.ijpe.2016.02.013.
[31] E.R.G. Pedersen, K.R. Andersen, Sustainability innovators and anchor draggers: a global expert study on sustainable fashion, J. Fashion Market. Manage. 19 (2015) 315–327, https://doi.org/10.1108/jfmm-08-2014-0059.
[32] J. Sarkis, M.M. Helms, A.A. Hervani, Reverse logistics and social sustainability, Corporate Soc.-Responsib. Environ. Manage. 17 (2010) 337–354, https://doi.org/10.1002/csr.220.
[33] K.K. Muduli, S. Luthra, S.K. Mangla, C.J.C. Jabbour, S. Aich, J.C.F. De Guimarães, Environmental management and the "soft side" of organisations: discovering the most relevant behavioural factors in green supply chains, Bus. Strategy. Environ. 29 (2020) 1647–1665, https://doi.org/10.1002/bse.2459.
[34] S.A.R. Khan, Z. Yu, H. Golpira, A. Sharif, A. Mardani, A state-of-the-art review and meta-analysis on sustainable supply chain management: future research directions, J. Clean. Prod. 278 (2021) 123357, https://doi.org/10.1016/j.jclepro.2020.123357.
[35] R. Stewart, N. Bey, C. Boks, Exploration of the barriers to implementing different types of sustainability approaches, Procedia CIRP. 48 (2016) 22–27, https://doi.org/10.1016/j.procir.2016.04.063.
[36] S.K. Sikdar, Sustainable development and sustainability metrics, AIChE Journal 49 (2003) 1928–1932, https://doi.org/10.1002/aic.690490802.
[37] A. Yıldızbaşı, C. Öztürk, D. Efendioğlu, S. Bulkan, Assessing the social sustainable supply chain indicators using an integrated fuzzy multi-criteria decision-making method: a case study of Turkey, Environ. Dev. Sustain. 23 (2020) 4285–4320, https://doi.org/10.1007/s10668-020-00774-2.
[38] R.L.H. Chiu, Social equity in housing in the Hong Kong Special Administrative Region: a social sustainability perspective, Sustain. Dev. 10 (2002) 155–162, https://doi.org/10.1002/sd.186.
[39] J.M. Harris, Sustainability and sustainable development, Int. Soc. Ecol. Econ. 1 (2003) 1–12.
[40] T. Al Khidir, S. Zailani, Going green in supply chain towards environmental sustainability, Global J. Environ. Res. (2009).
[41] M.N. Faisal, Sustainable supply chains: a study of interaction among the enablers, Bus. Process Manage. J. 16 (2010) 508–529, https://doi.org/10.1108/14637151011049476.
[42] P. Bohdanowicz, P. Zientara, E. Novotna, International hotel chains and environmental protection: an analysis of Hilton'swe care!programme (Europe, 2006–2008), J. Sustain. Tour. 19 (2011) 797–816, https://doi.org/10.1080/09669582.2010.549566.
[43] L. Preuss, Addressing sustainable development through public procurement: the case of local government, Supply Chain Manage. 14 (2009) 213–223, https://doi.org/10.1108/13598540910954557.
[44] J Zhan, L Wang, W Gao, H Li, C Wang, Y Huang, et al., Evaluatology: The science and engineering of evaluation, BenchCouncil Transactions on Benchmarks Standards and Evaluations (2024) 100162, https://doi.org/10.1016/j.tbench.2024.100162 [Internet]Mar 1Available from.
[45] Fisher R. The design of experiments [Internet]. 1935. Available from: http://ci.nii.ac.jp/ncid/BA23310168.
[46] F.E. Bowen, P.D. Cousins, R.C. Lamming, A.C. Farukt, The role of supply management capabilities in green supply, Prod. Oper. Manage 10 (2001) 174–189, https://doi.org/10.1111/j.1937-5956.2001.tb00077.x.
[47] H. Chen, S. Liu, X. Wanyan, L. Pang, Y. Dang, K. Zhu, X. Yu, Influencing factors of novice pilot SA based on DEMATEL-AISM method: from pilots' view, Heliyon. 9 (2023) e13425, https://doi.org/10.1016/j.heliyon.2023.e13425.
[48] A. Alsugair, K. Al-Gahtani, N. Alsanabani, G.M. Hommadi, M.A. Aloshan, An integrated DEMATEL and system dynamic model for project cost prediction, Heliyon. (2024) e26166, https://doi.org/10.1016/j.heliyon.2024.e26166.
[49] M. Nilashi, S. Samad, A.A. Manaf, H. Ahmadi, T.A. Rashid, A. Munshi, W. Almukadi, O. Ibrahim, O.H. Ahmed, Factors influencing medical tourism adoption in Malaysia: a DEMATEL-Fuzzy TOPSIS approach, Comput. Ind. Eng. 137 (2019) 106005, https://doi.org/10.1016/j.cie.2019.106005.
[50] J. Wu, H. Wang, L. Yao, Z. Kang, Q. Zhang, Comprehensive evaluation of voltage stability based on EW-AHP and Fuzzy-TOPSIS, Heliyon. 5 (2019) e02410, https://doi.org/10.1016/j.heliyon.2019.e02410.
[51] A.Khan Fahmi, N.T. Abdeljawad, M.A. Alqudah, Natural gas based on combined fuzzy TOPSIS technique and entropy, Heliyon. 10 (2024) e23391, https://doi.org/10.1016/j.heliyon.2023.e23391.
[52] Q. Hung DO, V.T. Tran, T. Tran, Evaluating lecturer performance in Vietnam: an application of Fuzzy AHP and Fuzzy TOPSIS methods, Heliyon. (2024) e30772, https://doi.org/10.1016/j.heliyon.2024.e30772.
[53] Z.A. Eldukair, B.M. Ayyub, Multi-attribute fuzzy decisions in construction strategies, Fuzzy. Sets. Syst. 46 (1992) 155–165, https://doi.org/10.1016/0165-0114(92)90128-q.
[54] M. Yazdi, F. Khan, R. Abbassi, R. Rusli, Improved DEMATEL methodology for effective safety management decision-making, Saf. Sci. 127 (2020) 104705, https://doi.org/10.1016/j.ssci.2020.104705.
[55] Z.A. Eldukair, B.M. Ayyub, Multi-attribute fuzzy decisions in construction strategies, Fuzzy. Sets. Syst. 46 (1992) 155–165, https://doi.org/10.1016/0165-0114(92)90128-q.
[56] S. Feng, L.D. Xu, Decision support for fuzzy comprehensive evaluation of urban development, Fuzzy. Sets. Syst. 105 (1999) 1–12, https://doi.org/10.1016/s0165-0114(97)00229-7.
[57] C.-T. Chen, Extensions of the TOPSIS for group decision-making under fuzzy environment, Fuzzy. Sets. Syst. 114 (2000) 1–9, https://doi.org/10.1016/s0165-0114(97)00377-1.
[58] R. Raut, B.B. Gardas, B. Narkhede, Ranking the barriers of sustainable textile and apparel supply chains, Benchmarking 26 (2019) 371–394, https://doi.org/10.1108/bij-12-2017-0340.
[59] M.R. Rashid, S.K. Ghosh, Md.F.B. Alam, M.F. Rahman, A fuzzy multi-criteria model with pareto analysis for prioritizing sustainable supply chain barriers in the textile industry: evidence from an emerging economy, Sustain. Oper. Comput. 5 (2024) 29–40, https://doi.org/10.1016/j.susoc.2023.11.002.
[60] D. Jianguo, Y.A. Solangi, Sustainability in Pakistan's textile industry: analyzing barriers and strategies for green supply chain management implementation, Environ. Sci. Pollut. Res. Int. 30 (2023) 58109–58127, https://doi.org/10.1007/s11356-023-26687-x.

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